Changes in the Status and Distribution of the Yellow-faced Bumble Bee (*Bombus vosnesenskii*) in British Columbia

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ABSTRACT

Bombus vosnesenskii, the distinctively-patterned Yellow-faced Bumble Bee, has undergone a significant and rapid range extension in British Columbia. Known initially from a single record of a few specimens at Osoyoos in 1951, it was put forward in 1996 as a species that warranted a threatened or endangered status because of its severely restricted range in the province. However, since 2000, the species has expanded north in the Okanagan Valley, west to the Similkameen Valley and, especially, has become firmly established in south coastal regions of the province, including Vancouver Island. Population increases in *B. vosnesenskii* to the south of BC have also been reported. The reasons for the rapid expansion of *B. vosnesenskii* in BC are unclear. Particularly in lowland southwestern BC, the range expansion might have been enhanced through escapes from colonies kept as pollinators of agricultural crops. The spread of *B. vosnesenskii* has coincided with the decline of *B. occidentalis*, so the former may have been introduced or naturally expanded its range at the same time as a niche was becoming vacant. Recent changes in agricultural practices, such as the increase of cranberry crops, may also be a factor, as might climate warming. Clarification of the reasons for the rapid population increases and range expansion of *B. vosnesenskii* is needed but, in the meantime, it should no longer be considered a candidate for species-at-risk listing.

Key Words: Hymenoptera; Apidae; Bombus; Bombus vosnesenskii; range expansion; British Columbia

INTRODUCTION

Trends in pollinator populations are most frequently reported as declines, and the range of causes include habitat loss, disease, pesticides, climate change and competition with invasive species (Goulson *et al.* 2008, Potts *et al.* 2010, Cameron *et al.* 2011). At a time when several species of North American bumble bees are becoming increasingly endangered (e.g., *Bombus occidentalis* Greene), others are exhibiting the opposite trend (Cameron *et al.* 2011, Colla and Ratti 2010).

Bombus vosnesenskii Radoszkowski, the distinctively-patterned Yellow-faced Bumble Bee, has undergone a significant and rapid range expansion in British Columbia (BC). This species can be readily recognized by its bold coloration: setae on the face, front of the thorax and a band on the fourth abdominal tergum are bright yellow; the remainder of the bee is covered by black setae (including all sternal segments) and the wings are dark brown (Fig. 1). In the Pacific Northwest, there are two similar-looking species, *Bombus caliginosus* (Frison) and *Bombus vandykei* (Frison). *Bombus caliginosus* has been reported only as far north as the Olympic Peninsula and Okanogan Valley in Washington State (Krombein *et al.* 1979) and we are aware of only a single photographic record of a male *B. vandykei* from BC (E-Fauna 2012). *Bombus vosnesenskii* is so readily recognizable, it is unlikely that any significant populations were previously overlooked in BC, and, instead, the dramatic increase in observations and collections documented in this paper represent

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a real change in the species' range and abundance in the province.

Bombus vosnesenskii ranges from southern BC south through Washington, Oregon, western Nevada and California to northern Baja California in Mexico (Thorp *et al.* 1983). Stephen (1957) noted that the bee was abundant in the coastal valleys and mountains of California and Oregon, but uncommon along the coast of southwestern Washington, Oregon and northern California. There it was mostly replaced by *B. caliginosus*. Around San Francisco Bay and Puget Sound, however, *B. vosnesenskii* was the more common of the two. Also, at that time, the bee was scarce north of the Columbia River and east of the Cascade Range and there were no records from eastern Washington or Idaho (Stephen 1957). For many years in BC, *B. vosnesenskii* was known from a single record of a few specimens collected at Osoyoos in 1925 (Buckell 1951) and, in 1994 and 1996 Scudder suggested that the severely restricted BC range warranted a threatened or endangered status for the species. At that time, he was unaware of the first known coastal BC specimen, a surprisingly early 1970 record from Burnaby in the Simon Fraser University collection. However, since 2000, the species has expanded north in the Okanagan Valley, west to the Similkameen Valley and, especially, has become firmly established in south coastal regions of the province. In many of these newly occupied areas, it is now among the most commonly noted bumble bee species.

MATERIALS AND METHODS

Data were collected from adult specimens of *Bombus vosnesenskii* from the collections of the Royal British Columbia Museum, Victoria, BC (RBCM); Department of Biological Sciences, Simon Fraser University, Burnaby, BC (SFU); Beaty Biodiversity Museum, University of BC, Vancouver, BC (UBC); and the Packer Collection, Biology Department, York University, Toronto, ON (PCYU). Photographic records were compiled from postings on the web sites indicated. In most cases, specimens were identified by the collectors and vetted by experts. Specimens with an asterisk were identified by the authors.

CANADA: BRITISH COLUMBIA: Abbotsford, blueberry farm, 49.130992N 122.260036W, 4.vi.2011, L. Button (1♀, SFU 741525), 49.718425"N 122.388556W, 12.vi.2011, L. Button (1♀, SFU 741644), 49.126239N 122.418817W, 12.vi.2011, L. Button (1♀, SFU 741742); Burnaby, 1.viii.1970, J. Hicks (1♂, SFU), 10.x.2007, S. Lam (1♂, SFU), 10.ix.2009, B. Rajala (1♂, SFU); 15.x.2009 K. Lee (1♂, SFU); Cawston, Forbidden Fruit Winery, 14.vii.2010, D.

Figure 1. *Bombus vosnesenskii* queen. BC, Victoria, 48.414722N 123.325111W, 27 April 2012, R.A. Cannings, RBCM ENT012-0022860.

Marks (1♀, RBCM); Duncan, Mount Tzuhalem Ecological Reserve, 48.78617N 123.63399W, 7.v.2010, E. Elle, L. McKinnon (3♀, SFU 726540, 727653, 727660), Quamichan Lake, Cowichan Garry Oak Reserve, 48.808556N 123.631250W, 14.v. 2009, E. Elle (1♀, SFU 719624), 3.v.2010, G. Gielens (1♀, SFU 726491); Fraser Valley Regional District, Onnink property, 49.07833N 122.38778W, 6.v.2004, C. Ratti (1♀, PCYU), Randhawa property, 49.12806N 122.41806W, 22.v.2003, C. Ratti (1♀, PCYU), 28.v.2003, C. Ratti (1♀, PCYU); Greater Vancouver Regional District, Banns property, 49.22361N 122.75333W, 19.vi.2003, C. Ratti (1♀, PCYU), 1.vii.2003, C. Ratti (1♀, PCYU), 5.vii.2003, C. Ratti (2♀,PCYU), 17.vi.2004, C. Ratti (1♀, PCYU), Bissett property, 49.08833N 123.16388W, 16.iv.2004, C. Ratti (1♀, PCYU), Edwards property, 49.14778N 123.06528W, 26.vi.2003, C. Ratti (1♀, PCYU), 4.vii.2003, C. Ratti (1♀, PCYU), 8.vii.2003, C. Ratti (1♀, PCYU), 12.vii.2003, C. Ratti (5♀, PCYU), Fisher property, 49.14472N 123.07333W, 17.iv.2003, C. Ratti (1♀, PCYU), 4.vi.2003, C. Ratti (1♀, PCYU), .iv.2004, C. Ratti (1♀, PCYU), 9.iv. 2004, C. Ratti (2♀, PCYU), 21.v.2004, C. Ratti (2♀, PCYU); Hopcott property, 49.24972N, 122.71722, 5.vii.2003, C. Ratti, (1♀, PCYU), Mayberry property, 49.19250N, 123.04556, 26.vi.2003, C. Ratti (2♀, PCYU), 26.vi.2003, C. Ratti (1♀, PCYU), 4.vii.2003, C. Ratti (1♀, PCYU), 12.vi.2004, C. Ratti (1♀, PCYU), 17.vi.2004, C. Ratti (6♀, PCYU), 22.vi.2004, C. Ratti (2♀, PCYU), McKim property,49.08139N 123.12056, 30.iv. 2003, C. Ratti (2♀, PCYU), 23.iv.2004, C. Ratti (1♀, PCYU), 14.v.2004, C. Ratti (2♀, PCYU); Surrey farms property, 49.09833N 122.79194W, 8.v.2003, C. Ratti (1♀, PCYU), 11.v.2003, C. Ratti (1♀, PCYU), 1.vi.2003, C. Ratti (1♀, PCYU), Tilson property, 49.15611N 122.43389W, 24.vi.2004, C. Ratti (1♀, PCYU); Lake Cowichan, 15 km E, Stoltz Meadows, 48.781667N 123.885250W, 17.v. 2009, L. McKinnon (1♀, SFU 717264), Mesachie Lake, Cowichan Lake Forestry Station, 48.81885N 124.1381885W, 23.vi. 2009, E. Elle (1♀, SFU 719077); Okanagan Falls, Blasted Church Vineyards, 3.vi.2010, D. Marks (1♀, RBCM), Blue Mountain Vineyards, 23.vi.2010, D. Marks (1♀, RBCM); Osoyoos, 20.vii.1925, E.R. Buckell (2♀, UBC); Pitt Meadows, blueberry farm, 49.260858N 122.701900W, 23.v.2011, L. Button (1♀, SFU 741145), 49.26092N 122.70444W, 5.vi.2011, L. Button (1♀, SFU 741341); Richmond, blueberry farm, 49.152308N 123.072550W, 5.vi.2011, L. Button (1♀ RBCM 012-000783); Vancouver, 16.ix.2006, E. Xia (1♂, SFU), 15.ix.2009, M. Sighan (1♂, SFU), Jericho Park, 30.vi.2011, S.A. Russell (1♀, UBC), Queen Elizabeth Park, 6.x.2006, D. Tanner (1♀, SFU), Stanley Park, 14-22.v.2008, J.A. McLean & A. Li (1♀, UBC), University of BC, Beaty Museum, 22.v.2010, R.T. Curtiss (2♀, UBC); 17.vi. 2010, R.T. Curtiss (2♀, UBC), University of BC Botanical Gardens, 24.vi.2011, S.A. Russell (3♀, UBC); 5.vii.2011, S.A. Russell (2♀, UBC); 8.vii.2011, S.A. Russell (2♀, UBC); 19.vii.2011, S.A. Russell (1♀, UBC), University of BC, Pacific Spirit Park, 3.vi. 2010, R.T. Curtiss (1♀, UBC); Victoria, Beacon Hill Park, 48.409715N 123.362835W, 20.vi.2007, L. Neame (1♀, SFU 709157); 48.409715N 123.362835, 20.vi.2007, L. Neame (1♀, SFU 709175); 48.409715N 123.362835W, 10.v.2007, L. Neame (1♀, SFU 709195); 48.409715N 123.362835W, 12.vi. 2007, L. Neame (1♂, SFU 709263); Victoria, 32 Chown Place, 17.iv.2010, M. Walsh (1♀, RBCM ENT012-002855*); Victoria, Oak Bay, Costain Green, 48.452754N 123.301117W, 8.vi.2007, L. Neame (1♂, SFU 709570); Victoria, Saanich, Royal Oak Drive, found dead, 14.vii.2011, C.R. Copley (1♀, RBCM ENT012-002856), Beaver Lake, Retriever Ponds, 17.vii.2011, C.R. Copley (1♀, RBCM ENT012-002859), Cedar Hill Park, 48.458103N 123.347128W, 7.v.2007, L. Neame (1♀, SFU 709464), Little Saanich Mountain, 48.520446N 123.420315W, 10.v. 2007, L. Neame (1♀, SFU 710398), Lochside Trail, found dead, 13.iv.2012, C.R. Copley (2♀, RBCM ENT012-002857, -002858), Prospect Lake, 25.v.2005, D.F. Fraser (1♀, RBCM ENTO12-005340); Victoria, 1909 Shotbolt Road, 48.414550N 123.326210W, 27.iv.2012, R.A. Cannings (1♀, RBCM ENT012-0022860); Victoria, University of Victoria, 14.ix.2009, C. Bruckal (1♂, RBCM ENT012-002852*), L. Dumoulin (1♂, RBCM ENT012-002853*), 21.ix.2009, R. Pretty (1♂, RBCM ENT012-002854*); Victoria, View Royal, Thetis Lake Regional Park,

48.466917N 123.466278W, 29.vi.2005, E. Elle (1♂, RBCM 012-000784).

Identifiable photographs of *B. vosnesenskii* from BC are also available. On the E-Fauna BC (2012) website, photos are posted from Crescent Beach, Nanaimo, Port Alberni, Richmond, Saanichton, and Vancouver. The Crescent Beach photo (#10577), from 14 July 2007, is the earliest taken. Flickr (2012) has identifiable photos from Vancouver but the BugGuide website (2012) has no BC photographs.

RESULTS AND DISCUSSION

The present known range of *Bombus vosnesenskii* in BC is shown in Fig. 2. Winston and Graf (1982) and MacKenzie and Winston (1984) reported on bee diversity in surveys of both commercial berry crops and native vegetation in the Fraser Valley in 1981 and 1982, but did not record *B. vosnesenskii*. However, of 2248 bumblebees collected, 25 were identified as "other" in MacKenzie and Winston, and could potentially have included *B. vosnesenskii*. The earliest record for the southwest coast of BC is from Burnaby in 1970; no others are known until 2000. Since then, the bee has been recorded frequently throughout the Lower Mainland. In 2000-2001, Tommasi *et al.* (2004) reported 38 individuals in urban surveys throughout Greater Vancouver. This compared to 801 *B. flavifrons* Cresson, 547 *B. mixtus* Cresson, 194 *B. melanopygus* Nylander, 16 of unknown species and 2 *B. occidentalis*, making *B. vosnesenskii* one of the less common species of the region. Ratti *et al.* (2008), in a crop pollination study in the Fraser Valley in 2003-04, found the species at 10 of 11 blueberry and cranberry fields surveyed. It was at the time still one of the less common *Bombus* species, comprising 39 of the 3,683 specimens collected. The bee was observed at all 15 sites surveyed at farms in the Fraser

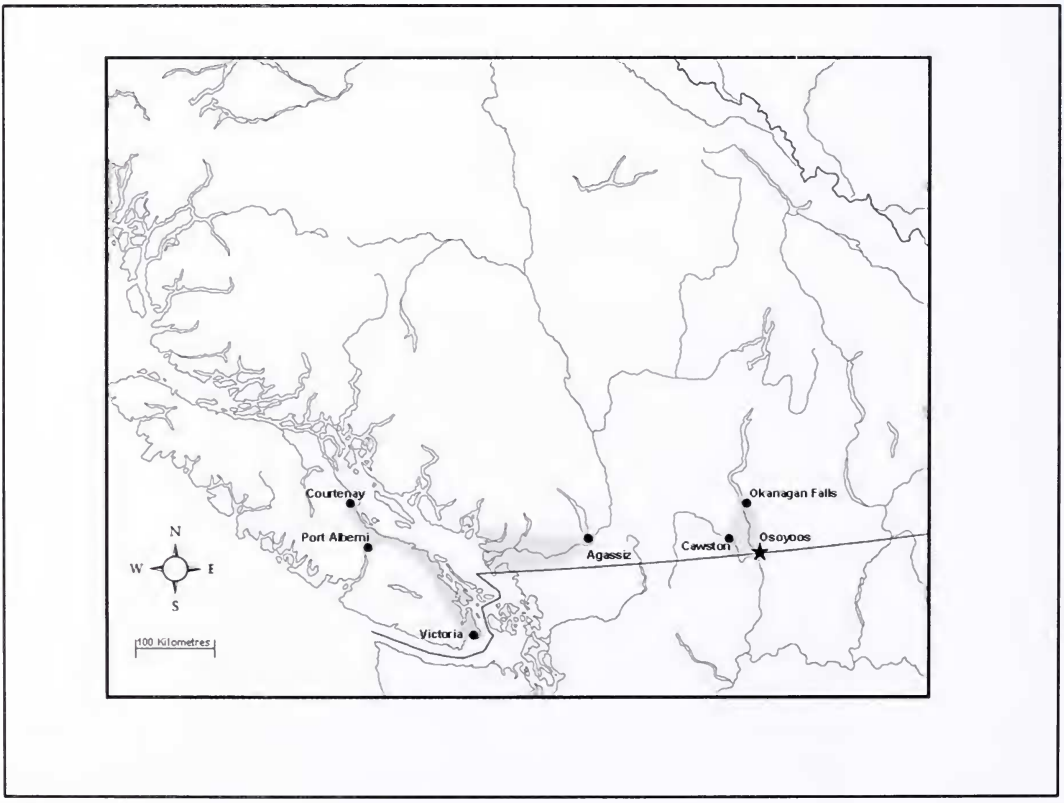

Figure 2. Map of southwestern British Columbia illustrating range expansion of *Bombus vosnesenskii*. Shaded area represents 2012 range. The symbol ★ represents the original 1925 record at Osoyoos.

Valley between 17 July and 21 September 2009 (Bains *et al.* 2009) and, by 2010, when they documented the bee in 25 of 64 sites surveyed from Delta east to Agassiz, Parkinson and Heron (2010) could state that it was one of the most common late season *Bombus* species in Greater Vancouver and the Fraser Valley.

Also in 2010, similar pollinator surveys in the South Okanagan and Similkameen valleys recorded *B. vosnesenskii* at three farms from Okanagan Falls south to Cawston (Marks and Heron 2010), the first records in the Interior since Buckell's initial collections in 1925. However, population expansion in the Okanagan has been much less obvious than on the South Coast. Other surveys in 2010 in the grasslands of the South Okanagan, in which about 10,000 pollinating insects were collected, recorded no *B. vosnesenskii* specimens (Elwell 2012). In 2012 we asked a number of biologists and naturalists throughout the Okanagan to watch for the distinctive species, but none were seen.

On Vancouver Island the Yellow-faced Bumble Bee is well established and expanding its range. In 1951 Buckell intimated that *B. vosnesenskii* could occur in Victoria; nevertheless, the first specimen record on the Island is from near Prospect Lake, Saanich, on 25 May 2005. Another specimen was collected the same year on 29 June at Thetis Lake Regional Park, during the third author's pollination research there. That year, she and her students pan-trapped at eight sites from Victoria to Campbell River and caught no other individuals. In 2007 they sampled with nets and pans at 19 sites on the Saanich Peninsula and collected seven specimens, out of 884 *Bombus* collected (less than 1%). In a net-only survey in the same area in 2012, 301 out of 2139 *Bombus* collected (14%) were *B. vosnesenskii*. In the Cowichan Valley in 2009, three were captured at three sites; in 2010 in the same region, four were collected at two localities. By 2009 the species was found as far north on the Island as Port Alberni (E-Fauna BC: photo #12718) and in 2012 it was photographed in Courtenay (T. Thormin, pers. comm.). *Bombus vosnesenskii* is now among the most common bumble bee species on the south coast of BC, especially in urban and farmland habitats.

Population increases in *B. vosnesenskii* to the south of BC have also been reported. In Oregon, Thorp (2008) conducted surveys for *Bombus franklini* (Frison) from 1998 to 2007 and noted that more than 50% of all *Bombus* reported in 2006 and 2007 were *B. vosnesenskii*, up from approximately 30% in 1998. Cameron *et al.* (2011) noted that *B. vosnesenskii* populations are stable in the western United States relative to historic data, at a time when several other *Bombus* species are declining.

The reasons for the rapid expansion of *B. vosnesenskii* in BC are unclear. One possibility, particularly in lowland southwestern BC, is that the bee could have been assisted in its range expansion through escapes from colonies kept as pollinators of agricultural crops. In 1991, *B. vosnesenskii* was tested as a greenhouse pollinator of tomatoes in Surrey south of Vancouver, although it was not intentionally released during that study (Dogterom *et al.* 1998). In adjacent Washington State, colonies are currently commercially available for crop pollination of raspberries, blueberries, cranberries, strawberries, peaches, plums, cherries and cabbage (Mike Juhl, pers. comm., http://www.hornetnestsfreeremoval.com/29601.html). Bumble bee escapes from greenhouses are well documented elsewhere, have contributed to the out-of-range introductions of other *Bombus* species, and have been implicated in the introduction of bumble bee diseases (Velthuis and van Doorn 2006, Colla *et al.* 2006). Greenhouse escapes likely resulted in the introduction of *B. vosnesenskii* to Australia (Planck 1999).

In BC the spread of *B. vosnesenskii* has coincided with the decline of *B. occidentalis* (Colla and Ratti 2010), so the former may have been introduced or naturally expanded its range at the same time as a niche was becoming vacant. As a study by Allen *et al.* (1978) showed, *B. vosnesenskii* has large colonies (including, in one, an estimate of the production of 650 queens), implying that it has an impressive capacity for colonization. Cameron *et al.* (2011) reported that *B. vosnesenskii* has a greater genetic diversity and a lower prevalence of the fungal pathogen *Nosema bombi* Fantham and Porter, compared to *B. occidentalis*, suggesting that these characteristics could serve as predictors of

population patterns. It is unknown, however, whether these observations indicate cause and effect, or if they apply to BC.

Recent changes in agricultural practices may also be a factor. Declines in some species of bumble bees have been attributed to the intensification of agriculture (Goulson *et al.* 2008), and even *B. vosnesenskii* populations have been shown to be closely linked to the proximity of natural habitat (Greenleaf and Kremen 2006). But *B. vosnesenskii* is frequently reported pollinating cultivated cranberries in Oregon, and in BC this industry has undergone considerable expansion in recent years. There are currently 1150 hectares under cranberry production, particularly in the Fraser Valley, as well as a few operations on Vancouver Island (Ministry of Agriculture 2012).

Modest population expansion in the South Okanagan-Simikameen, where we can find no reports of pollinator introductions, suggests that a natural cause is at work there. A number of species across a wide variety of taxa show changes in their distributions due to the effects of climate warming (Parmesan 2006, David and Handa 2010, Feeley 2012, Moreno-Rueda *et al.* 2012). Their life histories make insects especially good at adapting quickly to changes in the environment (Robinet and Roques 2010), so the spread of *B. vosnesenskii* may be facilitated by anthropogenic climate change.

Clarification of the reasons for the rapid population increases and range expansion of *B. vosnesenskii* is needed but, in the meantime, it should no longer be considered a candidate for species-at-risk listing.

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